CENTRAL ASIA NATURAL RESOURCES MANAGEMENT PROGRAM

TRANSBOUNDARY WATER AND ENERGY PROJECT

PROPOSALS FOR IMPROVED WATER AND ENERGY MANAGEMENT IN THE SYR DARYA RIVER BASIN

DRAFT FOR DISCUSSION

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

bcm	Billion cubic meters
BVO	River Basin Organization
CAPS	Central Asian Power System
DSS	Decision Support System
GWh	Gigawatt hour
ha	Hectares
ICWC	Interstate Commission for Water Coordination
IWEC	International Water and Energy Consortium
JSC	Joint Stock Company
kWh	Kilowatt hour
mcm	Million cubic meters
MW	Megawatt
SIC	Scientific Information Center
tcm	Thousand cubic meters
TEFEP	Transboundary Electricity and Fuel Exchange Pool
TWEP	Transboundary Water and Energy Project
UDC	Unified Dispatch Center
US $	United States Dollars
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

Purpose of Report

The Central Asia Transboundary Water and Energy Project (TWEP) of USAID is contracted with PA Government Services, Inc., under the Central Asia Natural Resources Management Program. One of the main areas of interest for TWEP is the Syr Darya Basin and the linkage between the operation of water storage and hydroelectric stations on the Naryn River in Kyrgyzstan and downstream irrigation demands, mainly in Uzbekistan and Kazakhstan.

The purpose of this Report is to describe the present situation, identify the main problems, assess possible remedial measures, and recommend measures for improved water and energy management in the Syr Darya Basin. This Report has been prepared with careful regard to the interests, sensitivities and hard work done to date by the countries involved. Its recommendations only seek to build on the agreements reached so far. The Report would be used to promote consensus among basin countries on measures that can improve regional water and energy management in the near term.

Background

The water resources of the Syr Darya Basin have been developed by a system of reservoirs, hydroelectric power plants, diversion dams, pumping stations, and major canals (Figure 1). These facilities irrigate areas of about 410,000 hectares (ha) in Kyrgyzstan, 271,000 ha in Tajikistan, 1,883,000 ha in Uzbekistan and 786,000 ha in Kazakhstan. The largest reservoir with a capacity of 19.5 billion cubic meters (bcm) is at Toktogul on the Naryn River, a tributary that accounts for about 30 percent of the water of the Syr Darya. The Toktogul Power Plant has an installed capacity of 1,200 megawatts (MW), and four downstream hydroelectric plants have an installed capacity of 1,670 MW. This complex of hydroelectric power stations in Kyrgyzstan is known as the Naryn Cascade. Other hydroelectric projects on the tributaries of the Syr Darya in Uzbekistan have a capacity of about 1,500 MW. The Kairakum Reservoir (Tajikistan) and the Chardara Reservoir (Kazakhstan) on the main stem of the Syr Darya have hydropower plants with a capacity of 125 MW and 100 MW, respectively.

During the Soviet period, the power and irrigation facilities of the Syr Darya and the Amu Darya, the other major river of the Aral Sea Basin, formed part of an integrated water and energy system. Large reservoirs in the mountainous upstream countries provided water supply for irrigation in the downstream countries and generated hydropower. Kyrgyzstan and Tajikistan supplied hydroelectric power in the summer months (April through September) of high river flows, and received the fuel (oil, gas, and coal) needed to operate their combined heat and power plants and natural gas systems in the winter months (October through March). This exchange of power and fuel took place in the context of a centrally planned economy.

Soon after independence, the five Aral Sea Basin countries agreed to maintain the water sharing and water distribution rules established during the Soviet times. They also agreed to establish the Interstate Commission for Water Coordination (ICWC) as the body responsible for the definition of allocations in line with these rules. At the same time, the two existing river basin organizations, the BVO Amu Darya and the BVO Syr Darya, became a part of the ICWC structure.

In contrast, since the early 1990s, the Aral Sea Basin countries have operated their electric power systems to a large extent as independent power systems. This has created problems for Kyrgyzstan since it lacks the financial resources to purchase fuel. In view of the potential for conflicts between hydroelectric power production and irrigation, annual water and energy sharing agreements have been negotiated between the Syr Darya Basin countries since the early 1990's. The annual agreements spell out fuel and power transfers between the countries and the releases from Toktogul Reservoir.

The principles underlying these agreements were formalized in the1998 Framework Agreement between Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan "On the Use of Water and Energy Resources of the Syr Darya Basin". The main articles establish that: (i) hydroelectricity that is in excess of the needs of Kyrgyzstan, and produced at the Naryn Cascade by water releases from Toktogul Reservoir requested by Kazakhstan and Uzbekistan, is transferred in equal amounts to Uzbekistan and Kazakhstan, and (ii) these transfers are compensated by Uzbekistan and Kazakhstan in equivalent amounts of energy resources, such as coal, gas, and oil, or in monetary terms as agreed upon.

Water and Energy Management Issues

Kyrgyzstan has sufficient electric power production capacity to meet its annual demand despite its large seasonal fluctuation. However, there are two major difficulties in making full use of this power production capacity. The first difficulty is that the bulk of power production is hydroelectric and comes from a multiple purpose water resource. Therefore, the production of hydroelectric power cannot follow the same seasonal pattern as that of the domestic electricity demand. In stead, the power supply system must rely on a regime of summer hydroelectric power export and winter fuel imports for power production by combined heat and power plants. The second difficulty is that electricity tariffs are considerably below cost-of-service levels and there is a high level of commercial losses. This results in power plants not earning enough revenue to purchase fuel. Therefore, the availability of fuel is directly linked to the hydroelectric exports, which in turn vary substantially from year to year depending on water demand downstream.

However, it must be recognized that even if there were no downstream use of water, Kyrgyzstan would still need considerable fuel supplies for the production of heat. Therefore, the regime of summer hydroelectric exports against fuel imports may impose some constraints on hydroelectric production in winter. But it also provides the means for Kyrgyzstan to obtain fuel which otherwise could not be purchased solely from the revenue available from heat or electricity billings. As a result and in addition to the benefit of good relations with its neighbors, it is in the best interest of the Kyrgyz heat and power sector to continue to fully cooperate in water and energy issues with the downstream countries.

In the summer, the power needs of Kyrgyzstan can be met by Toktogul Reservoir releases of about 3.5 bcm. In most years, the downstream users ask for higher flows. In recent years, the release from Toktogul Reservoir during the summer averaged 5.5 bcm, and ranged from 6.5 bcm to 3.5 bcm. Therefore, the surplus hydroelectricity that is available to be exchanged for fuel also varies considerably from year to year. This can lead to problems for Kyrgyzstan whose fuel needs are relatively constant, but their supply is linked to wide variations from year to year in the water needs of the Middle and Lower Syr Darya.

An uncertain fuel supply creates an incentive for Kyrgyzstan to maximize winter power generation at the Naryn Cascade. These problems are compounded by a sharp rise in the

Kyrgyz winter electricity demand, stimulated by low tariffs, displacing coal and natural gas for heating, hot water and cooking. Kyrgyzstan now faces a winter electric energy demand that is twice that of the Soviet period. The electric energy demand on a typical winter day is now three times the summer demand. This has led to a sharp rise in the loads on urban distribution systems and very high technical and non-technical losses.

As a result, since 1990, winter releases from Toktogul Reservoir have been higher and summer releases correspondingly lower than in the Soviet period. This has caused the main downstream users, Uzbekistan and Kazakhstan, to be concerned over the availability of water from Toktogul Reservoir in the summer. The higher winter releases cannot be carried towards the Aral Sea because the Lower Syr Darya is blocked by ice jams in Kazakhstan. Therefore, large volumes of water have been diverted into the Arnasai Depression, damaging lands and infrastructure in Uzbekistan, and depriving the Syr Darya Delta and Northern Aral Sea of much needed water.

The annual water and energy sharing agreements are essentially energy exchanges with a zero net balance but the methods for accounting for these exchanges are not fully clear. Furthermore, the request for irrigation water from Toktogul Reservoir by the downstream countries are delayed and subject to change. Therefore, annual agreements are concluded too late or the quantities of water, electric power and fuel supplies specified in the agreement have to be changed during its term in response to the changes in the water demands of the downstream users. This can lead to problems for the operators of Toktogul Reservoir and for the downstream countries to plan the use of the summer surplus of hydroelectric power.

The operation of Toktogul Reservoir is unstable and could lead to emergency situations. In its operation of the reservoir, JSC Power Plants uses predictions of inflow for the coming season. However, such predictions are difficult to make and operational decisions cannot be made with confidence. If the operators are too cautious in the winter, there is a risk that the reservoir will completely fill in the summer, and there is a high risk of spilling water if downstream countries do not absorb all the hydroelectric generation in excess of Kyrgyzstan needs. This situation took place in August 2003 when the reservoir was full and water had to be released through spillways of the Naryn Cascade because prices export electric power could not be agreed. Thus, water that could have been used to produce electricity was wasted. On the other hand, if the operators release too much water in the winter there is a risk that the reservoir might not fill enough during the summer to leave an adequate reserve for the following winter.

The managers of the Middle Syr Darya, BVO Syr Darya, face similar problems in predicting the water resource available from tributaries downstream of Toktogul Reservoir. An estimate made early in the late spring may prove to be too high. Then, a downward adjustment has to be made after the farmers have made their planting decisions. Furthermore, these problems in prediction delay the determination of the water demands of Uzbekistan and Kazakhstan from Toktogul Reservoir.

Measures to Improve Water and Energy Management and Interstate Cooperation

It follows from the previous section that there is a need to: (a) improve the operating rules of Toktogul Reservoir; (b) put in place better mechanisms for the downstream users to produce more timely and accurate request for water from Toktogul Reservoir; and (c) streamline the process of agreements on power and fuel exchanges to stabilize fuel supplies to Kyrgyzstan.

Over fifteen possible remedial measures were evaluated. They range from improved operation of reservoirs and energy loss reduction in Kyrgyzstan to improved arrangements for fuel and power exchanges, and reforms and investments in the regional energy and water sectors. The analysis shows that the following measures can improve water and energy management in the near term.

The Toktogul Operating Rules, described in this Report, would make the operation of the reservoir more responsive to the demands of Uzbekistan and Kazakhstan, particularly in years of low runoff in those countries. The Rules would provide the downstream countries with the opportunity to save water in Toktogul Reservoir during years when other water resources are plentiful, for use in subsequent "dry" years when other water resources are low. The Rules would also make winter and summer power production more predictable, and prevent over-filling or completely emptying of the reservoir.

The main Rules proposed for operating Toktogul Reservoir are:

(a) Rule 1: Target average releases should be agreed for the summer months (April-September) and winter months (October-March), the sum of which should be not much different from the long-term average river inflow to the reservoir less the net reservoir losses. In testing these rules, 5.5 bcm has been adopted as the target average release for the summer, because this has been the average release since 1995, with variations from year to year in accordance with the 1998 Agreement. The annual average river flow is 12.5 bcm, so the target average winter release has been assumed to be 7.0 bcm.

(b) Rule 2: Kazakhstan and Uzbekistan can vary their water withdrawals from Toktogul Reservoir during the summer, within constraints of: (a) maximum and minimum balances of the water saving account for the reservoir; (b) minimum water releases for electricity generation for Kyrgyzstan and diversion to canals on the Naryn River; and (c) availability of storage space in the reservoir. Using the rules to simulate management of the reservoir during previous years shows that during dry periods up to 1.0 bcm extra water could safely have been withdrawn from the reservoir to ease the downstream shortages;

(c) Rule 3: Reservoir Rule Curves, based on the water stored at the beginning of each 10-day period, will determine if the target releases for the summer and winter (Rule 1) need to be increased or decreased to avoid emptying or overfilling of the reservoir. The Rule Curves will also be used to limit the amount of water that can be saved (Rule 2).

An Operational Guideline for the Naryn Cascade would help implement the proposed Toktogul Operating Rules in harmony with the daily and hourly management of water releases to account for short-term fluctuations in electricity demand.

A Decision Support System (DSS) for the Middle Syr Darya, also described in this Report, would enable the BVO Syr Darya to predict in April what will be the available water resources during the summer irrigation season in addition to the seasonal target releases from Toktogul Reservoir, and hence provide early and accurate notice of water demands on the Toktogul Reservoir. This would allow time for the water and energy managers in Uzbekistan and Kazakhstan to plan the use of the basin's total water resources and summer surplus of hydroelectric power. The DSS would also allow timely changes in the water allocation plans throughout the irrigation season.

These management tools are being developed by PA Government Services working with officials in JSC Power Plants and BVO Syr Darya. There is also a need for more complete, transparent, and timely reporting of reservoir operations, river flows, and canal head

diversions. The management tools could be linked to better data and information reporting and sharing between the countries.

A Multi-Year Electricity-Fuel Exchange Protocol is needed as an urgent measure to avoid annual fluctuations in fuel deliveries to Kyrgyzstan. It should be possible to agree on (a) an average annual hydroelectric power transfer and (b) an average annual fuel delivery. The Protocol would give Kyrgyzstan more stable fuel supplies in exchange for the variable exports of hydroelectricity generated at the Naryn Cascade by water releases from Toktogul Reservoir requested by Uzbekistan and Kazakhstan. This would simplify and possibly avoid the need for annual negotiations and political approval on fuel and power transfers. Annual agreements on releases from Toktogul Reservoir would be arrived at through the management tools described above. This Report describes two possible modalities for such a Protocol.

A Regulatory Framework for the smooth implementation of the 1998 Framework Agreement is a desirable medium term goal. Several articles in the 1998 Framework Agreement refer to the need to conduct additional work in areas that would facilitate the implementation of the principles set in the Agreement. This Report offers suggestions to address some of the commitments made in the 1998 Agreement through a Regulatory Framework. One of these commitments refers to guidelines for the determination of a single tariff policy. The other commitment is the possible design of an energy exchange pool, associated to the single tariff policy, to facilitate energy trading. The exchange pool would in the medium term replace the above Multi-Year Electricity-Fuel Exchange Protocol. The pool also would be a natural step towards the creation of an International Water and Energy Consortium (IWEC).

New Water Storage Projects. The Report is concerned with better management of existing infrastructure. However, there are several water storage and water transfer projects underway or planned in the basin. This new infrastructure could contribute to more national independence of water management decisions and more stable river management. It is recommended that these projects be included in future detailed studies of the longer-term regional water management arrangements.

Major changes in the institutional arrangements for regional water management are not considered appropriate in the medium term. But there is a need to strengthen the seasonal planning, monitoring, and information sharing function of the BVO Syr Darya. There is also a need for the Syr Darya Basin countries to explore the options for improved operation of the Kairakum and Chardara Reservoirs to further reduce losses to the Arnasai Depression to acceptable levels and improve flows towards the northern Aral Sea in winter.

Energy Sector Reforms to improve overall governance of all energy resources in the Syr Darya Basin countries are a key part of any permanent solution to the problem of water and energy management. The energy sectors in the Syr Darya Basin countries and in particular the Kyrgyz energy sector suffer from numerous structural and institutional weaknesses including tariffs well below cost of service and inadequate metering, billing and collection practices. These fundamental defects both contribute to inefficient use of energy resources and prevent financing of maintenance and rehabilitation of existing facilities and investment in new ones.

Recommendations

This Report, therefore, recommends that:

(a) The Syr Darya Basin countries agree to adopt and implement the Toktogul Reservoir Operating Rules described in this Report that are more responsive to the water demands of Uzbekistan and Kazakhstan, particularly in years with low runoff in those countries; and

(b) The Syr Darya Basin countries agree on a Multi-Year Electricity-Fuel Exchange Protocol that would give Kyrgyzstan more stable fuel supplies in exchange for the variable exports of hydroelectricity generated at the Naryn Cascade by water releases from Toktogul Reservoir requested by Uzbekistan and Kazakhstan.

Items (a) and (b) might be in the form of an Addendum to the 1998 Framework Agreement. It is also recommended that the management tools for operating the Naryn Cascade and the Middle Syr Darya be adopted by JSC Power Plants and the BVO Syr Darya, respectively. This is a refinement of existing procedures and does not require a formal agreement.

The actions recommended above will lead to more effective water and energy resource management in the Syr Darya Basin. The management tools, linked to better data and information reporting, are not just short-term remedies. Their intent is to diminish friction between the four countries and promote lasting cooperation in water and energy management.

The Syr Darya Basin countries could also consider as a medium term measure the development of a permanent and practical Regulatory Framework that is consistent with the principles stated in the 1998 Framework Agreement and would guide its smooth implementation. The Regulatory Framework would set clear rules for a single tariff schedule, including power transmission and fuel transport fees, and establish an energy exchange pool. This energy exchange pool would in the medium term replace the above Multi-Year Electricity-Fuel Exchange Protocol as a step towards the joint operation of regional facilities in line with the objectives of the International Water and Energy Consortium.

At the same time, it is recommended that Kyrgyzstan vigorously pursue energy sector reforms to reduce energy losses and bring tariffs in line with full costs of service. This would help reduce winter energy demand and increase domestic revenues. The additional revenue can be used to improve the power system and supplement export revenues to purchase fuel.

1. PRESENT SITUATION

1.1. Water Management

1. The water resources of the Syr Darya Basin have been developed by a system of reservoirs, hydroelectric plants, diversion dams, pumping stations, and major canals (Figure 1 and 2). These facilities irrigate areas of about 410,000 hectares (ha) in Kyrgyzstan, 271,000 ha in Tajikistan, 1,883,000 ha in Uzbekistan and 786,000 ha in Kazakhstan. The Naryn River, the main tributary of the Syr Darya that supplies about 30% of the water resources available for irrigation diversions, is controlled by the Toktogul Reservoir in Kyrgyzstan. The other reservoirs are located downstream of Toktogul and are much smaller. Kairakum Reservoir in Tajikistan and Chardara Reservoir in Kazakhstan are both situated on the main stream of the Syr Darya. Reservoirs on tributaries include Andijan on the Karadarya, and Charvak on the Chirchik, both located in Uzbekistan.

Water Sharing Agreements and Distribution Limits

2. The Aral Sea Basin countries agreed in 1992, within a year of their independence, to adopt water sharing and water distribution rules established during the Soviet era. They also agreed to establish the Interstate Commission for Water Coordination (ICWC) as the body responsible for the definition of seasonal water allocations in line with these rules. The major part of the water resources of the Syr Darya Basin are under the mandate of the ICWC. They include water flows in the main stem of the Naryn and Syr Darya rivers between Toktogul Reservoir and Chardara Reservoir and the water flows of other tributaries and drains that reach the main stem. A minor part of the basin's water resources are national and transboundary rivers subject to bilateral agreements.

3. The transboundary water resources are distributed in accordance with Canal "Limits" that were established during the Soviet era. The Canal Limits define water diversions at each canal head and at each point where canals cross international borders. The countries accept these Canal Limits, though Kyrgyzstan and Tajikistan have outstanding claims to increase irrigation diversions. Under the Canal Limit system the available water supply is allocated among the users; it is not delivered to meet demands derived from irrigation requirements. This is a logical approach in an area where the rainfall during the summer irrigation season (April through September) is very low and where the crop water requirements vary little from year-to-year.

4. In addition to the canal diversions, an allowance is made for flows to the Aral Sea and some environmental flows within Kazakhstan. If the available resource is insufficient to meet all canal and environmental needs, the diversions planned earlier in the season are reduced by a common adjustment factor. No upward adjustment is made if the supply is more than adequate. Allowances for water flows to the Aral Sea and environmental discharges are also reduced when water resources are short.

Water Resources of the Syr Darya

5. The requirement of Uzbekistan and Kazakhstan for water from Toktogul Reservoir varies considerably from year to year as indicated in Table 1, depending on the availability of water resources of the Syr Darya between Toktogul Reservoir and Chardara Reservoir. These water resources comprise: (i) releases from Andijan and Charvak Reservoirs on the outer bounds of the Syr Darya Basin, (ii) regulation of the Kairakum and Chardara Reservoirs on

the Syr Darya, and (iii) side inflows, which comprise the net of flows from drains, small tributaries and groundwater (Table 1).

Table 1: Water Resources (bcm) of the Syr Darya Upstream of Chardara Dam During Summer (April-September)

TYPICAL HIGH, LOW AND MEDIUM YEARS OF WATER RESOURCE AVAILABILITY	1996	2000	2002	2003
Toktogul Reservoir				
- Release from Toktogul Reservoir	**6.2**	**6.5**	**3.6**	**4.9**
Other Water Resources (besides Toktogul)				
- Release from Andijan Reservoir	2.7	1.9	4.8	4.6
- Release from Charvak Reservoir	5.0	3.7	6.1	5.5
- Regulation of Kairakum Reservoir	1.5	2.2	1.9	1.7
- Regulation of Chardara Reservoir	4.4	4.5	4.3	4.4
- Side Inflows	11.0	7.5	12.7	14.2
Total of Other (non-Toktogul) Resources	**24.6**	**19.8**	**29.8**	**30.4**

6. Only releases from Toktogul Reservoir and the other reservoirs on the main stream are fully controllable. The Andijan and Charvak Reservoirs have limited storage capacity so their releases are mainly determined by inflows during the summer. The side inflows cannot be controlled at all. Furthermore, the uncontrollable resources vary considerably from year to year, with a range that is much more than can be compensated for through operation of Toktogul Reservoir. It is the unpredictability of the side inflows and inflows to the rim reservoirs Charvak and Andijan that create difficulties in managing basin water resources.

7. Kazakhstan and Uzbekistan would thus prefer to partly balance the variations in the inflows to the rim reservoirs and side inflows during the summer by releasing different volumes of water each year from Toktogul Reservoir. When other water resources are plentiful, releases from Toktogul can be low and vice versa. Since 1990, Toktogul Reservoir has provided from 15% to 35% of the total summer water resource of the Syr Darya. This is illustrated in Table 1 that shows water resource availability during the summer in a medium, dry, and wet years.

Water Management Institutions

8. When the Aral Sea Basin countries established the ICWC in 1992 they agreed that the two river basin organizations (BVO), the BVO Amu Darya and the BVO Syr Darya, would become part of the ICWC structure. The ICWC has a small permanent secretariat located in Khodjend, Tajikistan. The Scientific Information Center (SIC) of the ICWC, in Tashkent was formed later as a research and information arm of the ICWC.

9. The ICWC consists of the officials in charge of water management in each of the five member countries (Ministers of Water). Quarterly meeting of the ICWC are conducted to define and adjust seasonal water allocations and reservoir operations that have been developed by BVO Syr Darya in consultation with the basin countries. The ICWC does not have authority to enforce its decisions on all canal diversions and reservoir releases.

10. The BVO Syr Darya is responsible for the planning and monitoring of seasonal water allocations in the Syr Darya Basin. It is also charged with the day-to-day operation and maintenance of regional water infrastructure in Uzbekistan, the main elements being diversion dams on the Naryn and Karadarya and the main headworks and feeder canal head reaches on the Syr Darya upstream of Chardara Reservoir. BVO Syr Darya also manages national facilities on the Chirchik River in Uzbekistan. The central office of BVO Syr Darya is located in Tashkent, and there are four branch offices in Uzbekistan.

11. The BVO Syr Darya does not operate any of the key reservoirs. The operation of the Naryn Cascade is under the JSC Power Plants of Kyrgyzstan. Other major reservoirs and hydroelectric stations are mostly operated by national energy agencies. BVO Syr Darya makes requests to all reservoir operators for water releases during the important summer irrigation season. During the winter months (October through March), water releases are determined mainly by power generation needs in consultation with the BVO Syr Darya.

12. Chardara Reservoir and the section of the Syr Darya from the reservoir down to the Aral Sea, all situated in Kazakhstan, come under the control of the Aral Syr Darya BVO. This is a Kazakhstan government agency operating under the Kazakhstan Committee of Water Resources of the Ministry of Agriculture. This BVO has its head office in Kyzyl-Orda and a branch office in Shymkent. It controls the main offtakes and pumping stations, and two main collectors which discharge back into the Syr Darya. Local drainage and sinks are controlled by local agencies.

Reservoir Operation

13. When it makes plans for summer water allocations, the BVO Syr Darya relies on forecasts provided by the hydro-meteorological services to estimate tributary and drainage return flows. Water releases are made from Toktogul Reservoir to complete the balance between the estimated water supply in the rest of the basin and the water demand. Summer water releases from Toktogul Reservoir produce hydroelectric power that exceeds the needs of Kyrgyzstan. The surplus electric power can be exported to Uzbekistan and Kazakhstan.

14. In recent years, Kyrgyzstan was initially asked for a summer release from Toktogul Reservoir of 6.0 - 6.5 billion cubic meters (bcm) of water in pre-season agreements. But when downstream runoff turned out to be high, Kyrgyzstan was asked to cut water releases in 1998 and 2002 to 3.7 bcm and 3.6 bcm respectively. In 2003 the downstream users did not call for additional water releases from Toktogul because of high flows in the other tributaries. The release of 4.8 bcm in 2003 was mainly made to meet the summer electric power needs of

Kyrgyzstan and to control the reservoir level. Although previously agreed requests for summer releases have been largely met, there have been periods when there was inadequate water available to meet all required diversions downstream.

15. During the Soviet period, there was no incentive for Toktogul Reservoir operators to maximize the electric power output of the Naryn Cascade in the winter because the Central Asia Power System (CAPS) operated as a power pool for the Aral Sea Basin, provided responsive and reliable electric energy in the region (including Kyrgyzstan). Hence, the winter water release was low and the summer water release correspondingly high. An uncertain fuel supply after 1990 has created an incentive for Kyrgyzstan to maximize winter power generation at the Naryn Cascade, with the major water releases from Toktogul Reservoir during winter. The higher winter water flows exceed the capacity of the Lower Syr Darya and water has been spilled into Arnasai Depression in Uzbekistan in recent times.

16. However, the change in operation of Toktogul Reservoir after 1990 hasn't reduced the irrigation releases substantially. Before 1990, the average summer water release amounted to 8.1 bcm, but large releases were made at times to prevent over-filling of the reservoir. The average release for irrigation was around 6.5 bcm. Recent summer water releases have also been around 6.5 bcm when necessary, but reductions in water releases when other resources have been plentiful have dropped the average to 5.5 bcm.

1.2. Energy Management

The Regional Power System

17. The Syr Darya Basin countries remain connected to the CAPS. Their individual installed capacities are Uzbekistan (11,500 megawatts or MW), South Kazakhstan (2,360 MW), Kyrgyzstan (3,690 MW), and Tajikistan (4,300 MW). However, due to lack of investment and aging of the power plants, their combined current operating capacity is less than 19,000 MW. Most of the thermal plants in Uzbekistan are conventional gas-fired steam plants. In Kyrgyzstan and Tajikistan the thermal plants are multi-fuel plants that also provide steam for district heating. The plants in South Kazakhstan are predominantly coal-fired plants. The major hydroelectric plants are the 2,870 MW Naryn Cascade in Kyrgyzstan, 1,500 MW on the Syr Darya tributaries in Uzbekistan, and 4,300 MW in Tajikistan. A 500 kilovolt transmission grid interconnects the main power plants and load centers. The operating capacity of Uzbekistan, the largest part of the system, is considerably less than its installed capacity because much of the equipment is in need of replacement or rehabilitation.

18. Prior to independence, the CAPS was operated as an integrated system under the control of the Unified Dispatch Center (UDC) in Tashkent. Transfers of hydroelectric power from Kyrgyzstan and Tajikistan in the summer months of high river flows were balanced by supplies of fuel (oil, gas, and coal) to operate their thermal plants in the winter. The CAPS acted essentially as a single, self-contained, utility company. But, since the early 1990s, the Aral Sea Basin countries have operated their electric power plants as independent power systems. Power exchanges still take place, but at a much lower level than in the Soviet period. The hydroelectric plants continue to provide frequency control and system stability.

19. It should be pointed out that during the Soviet period the dispatch of electric power, the downstream releases of water, and the supply of fuels to Kyrgyzstan for its thermal power plants were responsive only to demand, with no consideration for financial and economic justification since all facilities were owned and operated within the Soviet system.

20. The energy sectors in the Syr Darya Basin countries suffer from numerous structural and institutional weaknesses that stand in the way of an integrated market for fuel supplies and electric power. Fuel prices are distorted, due to a lack of market forces and stringent government controls. In general, regulatory reform of natural monopolies is lacking. For the electric power sector, tariff levels are well below the cost of operations, making it impossible to finance maintenance and rehabilitation of existing electric power facilities, let alone invest in new facilities. Retail tariffs are about 1.0-1.5 U.S. cents / kilowatt-hour (kWh), compared to an average of 6.0-8.0 U.S. cents / kWh for self-sufficient power utilities worldwide.

The Kyrgyz Power System

21. In Kyrgyzstan, these problems are compounded by a sharp rise in winter electricity demand, stimulated by low tariffs, displacing coal and natural gas for heating, hot water and cooking. While the total electric energy demand in Kyrgyzstan has not increased since the Soviet era, its winter demand has doubled. The electric energy demand on a typical winter day is now three times the summer demand. This has led to a sharp rise in the loads on urban distribution systems and very high technical and non-technical losses (over 40 percent of gross consumption). Because Kyrgyzstan is unable to purchase sufficient fuel supplies, it aims to maximize winter power generation from the Naryn Cascade by increasing the outflows from the Toktogul Reservoir.

22. Based on average irrigation demands, the summer production of the Naryn Cascade is approximately 5,040 GWh and there are some 100 GWh produced by other small hydroelectric plants. More than enough to meet the summer electric energy demand of about 3,560 GWh in Kyrgyzstan. Nonetheless, there is still a “forced” thermal production of about 300 GWh associated with the production of hot water. Thus, during the summer there is on average a surplus of about 1,900 GWh of hydroelectric power for export. During the winter, the average output of the Naryn Cascade and small hydro is 6,490 GWh, substantially below the demand of about 8,140 GWh. The difference, 1,650 GWh should be supplied by thermal plants in Bishkek (680 MW) and Osh (50 MW). About 800 GWh of this average requirement of thermal power production in winter is associated with the demand for municipal and industrial heat.

23. It is therefore interesting that the multiple purpose use of the Toktogul Reservoir is a vital element of energy management in Kyrgyzstan. The Kyrgyz annual electric energy demand of some 11,700 GWh could perhaps be met almost exclusively with the average annual hydroelectric production of 11,630 GWh under a single-purpose, power driven, reservoir operation. But in that case two problems would arise for the Kyrgyz energy sector: a) there would be an inefficient use of fuel as the combined heat and power plants would only use their steam and hot water for heating and b) there would be no compelling reason for downstream countries to purchase any hydroelectric surplus from Kyrgyzstan with the fuel needed to supply the Kyrgyz demand for heat. Kyrgyzstan needs to import fuel, as domestic fuel resources are scarce.

1.3. Protocols and Agreements

24. Since the mid -1990’s, the Syr Darya Basin countries have negotiated annual agreements on water and energy exchanges. Each year these agreements spelled out the summer releases from Toktogul Reservoir, the levels of summer power exports from Kyrgyzstan to Uzbekistan and Kazakhstan, and fuel and power transfers to meet the winter needs of Kyrgyzstan. The March 17, 1998 Framework Agreement between Kazakhstan, the

Kyrgyz Republic, and Uzbekistan "On the Use of Water and Energy Resources of the Syr Darya Basin" was adopted to formalize the underlying principles of these arrangements. Tajikistan became a party to the Framework Agreement on June 19, 1998.

25. The main articles of the 1998 Framework Agreement are:

(a) annual agreements to be reached on the summer operation of reservoirs on the Naryn Cascade;

(b) hydroelectric power, in excess of the needs of Kyrgyzstan, produced by irrigation releases to be transferred in equal amounts to Uzbekistan and Kazakhstan;

(c) the above transfers of hydroelectric power to be compensated in equivalent amounts of energy resources, such as coal, gas, electricity, and fuel oil, or in monetary terms as agreed upon;

(d) operation of the Kairakum Reservoir according to a regime agreed by the parties, and agreement that Uzbekistan and Kazakhstan will supply equal portions of electrical energy to Tajikistan while the reservoir fills, and be repaid in the same amount during the summer.

26 The Agreement has a five-year validity and is automatically renewed unless one of the parties objects. The initial validity period expired in March 2003. Despite some discussion about amending the agreement, no action was taken and the agreement is still in force.

27. Each year the parties to the 1998 Agreement meet to agree on operation of the Naryn Cascade and the levels of fuel and power transfers. Annual protocols spell out the agreements in considerable detail. They are not confined to the Toktogul issue and sometimes refer to water management decisions made by ICWC regarding other parts of the river system. A power or fuel exchange described in a protocol is sometimes also the subject of a bilateral agreement. As discussed below, the exchanges agreed are often changed during the year.

2. DEFINITION OF THE PROBLEM

2.1. Fuel Supply Constraints in Kyrgyzstan

28. On a year of average water releases from Toktogul Reservoir to meet irrigation requirements downstream, the Naryn Cascade can generate 11,455 GWh. Other small hydroelectric plants generate on average 190 GWh, and the electricity production of thermal plants associated with the current demand for district heating is 1,106 GWh. Given enough fuel is available the thermal plants can generate another 3,975 GWh not linked to heat demand. This may require rehabilitation of some equipment to ensure a reliable sustained operation since the plants have not run at this level since pre-independence times. Thus, the total production capability in the system is 16,726 GWh. The annual electricity demand in Kyrgyzstan is currently about 11,700 GWh. Therefore, on an annual average basis there is almost 43% electric energy production reserve. The firm energy of the hydroelectric system (i.e. the annual electric energy that can be produced under adverse hydrologic conditions) is approximately 8,750 GWh. Adding the total electric energy production capacity of thermal plants (5,081 GWh) the system firm energy supply is about 13,831 GWh. This is about 18% above total annual electric energy demand.

29. The peaking capacity (i.e. the instantaneous output not related to sustained water availability) of Toktogul hydroelectric power plant is determined by the level of the reservoir which controls the head on the turbines. The peaking capacity can vary from its maximum of 1,200 MW when the reservoir is at least half full to about 700 MW at the lowest operating level. The peaking capacity at the downstream hydroelectricity plants is almost constant at 1,670 MW. Thus the peaking capacity of Naryn Cascade ranges from 2,870 MW to about 2,370 MW. This lower value is close to the peak demand (i.e. the maximum instantaneous demand) of Kyrgyzstan in the winter, and far exceeds the peak demand in the summer. An additional 600 MW of peaking capacity is available in existing thermal plants. Thus the system currently has a minimum peaking capacity of 2,970 MW that gives it a capacity reserve of 25%. This should provide adequate reliability taking into account also unplanned or "forced" generation outages. Some problems may exist in the capacity of existing transmission to fully deliver peaking power to the load centers, and this is under investigation.

30. Based on the above, the Kyrgyz system has adequate electric energy production capacity and peaking capacity to meet demand. Furthermore, even under the Toktogul operating rules to meet irrigation needs downstream, the Kyrgyz hydroelectric and thermal system could cope with the very high seasonal variation in the demand for electricity and heat. But when the Toktogul Reservoir is operated to meet the downstream irrigation demands, a hydroelectricity surplus is created during the summer (April-September). This may contribute to a shortage in winter (October-March) to be met by the thermal power plants using fuel. Fuel resources are scarce in Kyrgyzstan. Therefore, Kyrgyzstan has to depend on Uzbekistan and Kazakhstan to provide reliable fuel supply in return for the summer hydroelectricity surplus.

31. The summer hydroelectric production that is available for export is, on average, 1,910 GWh. At current demand levels the average requirements for thermal generation in the winter are about 1,650 GWh. Adding 300 GWh of “forced” thermal generation in summer driven by hot water demand, the total average annual requirements of thermal generation reaches about 1,965 GWh. Thus, in electric power terms, there is a small deficit between summer hydroelectricity exports and thermal generation requirements during the year.

32. The situation is quite different in monetary terms. At the price levels currently agreed for electricity exports and fuel imports, there is a substantial "trade deficit" between the revenues generated by summer electricity exports and the cost of fuel required for thermal generation during the year. Under average water releases from Toktogul Reservoir, the export revenues would only suffice to run the thermal plants to the level driven by heat demand, and produce 1,100 GWh of the required 1,965 GWh.

33. The water demands on Toktogul Reservoir by Uzbekistan and Kazakhstan vary considerably from year to year, depending on the availability of other water resources in the Syr Darya Basin downstream of Toktogul Reservoir. Therefore, the summer surplus of hydroelectric energy that Kyrgyzstan can export is subject to the same year-to-year variations. The surplus can range from 3,000 GWh to about 300 GWh. Thus the balance between summer hydroelectric exports and annual required thermal generation can vary between a trade surplus of 1,035 GWh (3,000 GWh - 1,965 GWh) and a trade deficit of 1,665 GWh (1,965 GWh -300 GWh). The variability in annual fuel supply is a major problem for Kyrgyzstan whose annual fuel needs are relatively constant.

2.2. Unstable Reservoir Operation

34. In its operation of the reservoir, JSC Power Plants uses predictions of inflow for the coming season (provided by Kyrgyzstan Hydromet). However, such predictions are difficult to make and generally tend towards the mean water flow. Therefore, operational decisions cannot be made with a great deal of confidence. If the operators are too cautious in the winter, there is a risk that the reservoir will completely fill in the summer and produce a large summer power surplus that might be difficult to sell, given the lack of a regional wholesale power trade market. On the other hand, if the operators release too much water in the winter there is a risk that the reservoir might not refill in the summer, leaving no water reserves for the following winter. A further problem for the reservoir operators is that the request for water from the downstream users in the main summer irrigation season is delayed and subject to change.

35. The events of August 2003 are a dramatic illustration of the need for a more stable operating regime for the Toktogul Reservoir and for better arrangements to manage the sale of surplus hydroelectric power produced by the Naryn Cascade. In August the reservoir filled and water had to be released through the spillways of the downstream stations on the Naryn Cascade. Thus, water that could have been used to produce electricity was wasted, even though it is the lowest cost electrical power produced in the region. This situation was made worse when the operators had to further reduce the flow through the turbines of the Naryn Cascade because Uzbekistan and Kazakhstan (in accordance with the 1998 Framework Agreement) chose not to absorb power in exchange for water releases that they did not request.

2.3. Spills into the Arnasai Depression

36. The sharp increase in winter releases from Toktogul Reservoir has caused a major environmental impact. The re-regulation capacity of the downstream reservoirs, Kairakum in Tajikistan and Chardara in Kazakhstan, is not sufficient. Therefore, winter flows into Kazakhstan along the Lower Syr Darya have risen by over 30%, but ice jams limit the river's capacity to transport surplus flows to the Aral Sea. As a result, the excess water is spilled from Chardara Reservoir into the Arnasai Depression in Uzbekistan. Since 1992, more than 32 bcm of water have been spilled into the Depression. This has damaged land and

infrastructure and deprived the Syr Darya Delta and the northern Aral Sea of much-needed water.

2.4. Water Management Problems

37. There has been no difficulty to reach agreement on water resource management plans at the regular ICWC meetings, because the principles of water sharing and the responsibilities of individual countries to implement them are well known and accepted. But problems arise in the implementation of the plans, exacerbated by poor data and information sharing. Reports to ICWC on past performance are insufficiently complete and not fully transparent, and reports on water resource management are not regularly made available to the individual countries and basin water management organizations during the key summer irrigation season. There is also friction over the performance in sharing water and debts incurred in the past fuel and power exchanges.

38. BVO Syr Darya faces two problems in managing the Middle Syr Darya. One is the difficulty in predicting as early as possible in spring what will be the total available water resource in the summer. The second is the coordination and agreement of revisions to the water resource management plans throughout the season in an environment of uncertain water resources. If estimates of the water resources available early in the season prove to be too high, a sharp downward adjustment has to be made to the canal diversions in mid-season and this creates problems for the irrigators and farmers.

39. Although previously agreed requests for summer water releases from Toktogul Reservoir appear to have been met, there have been periods when there was inadequate water available to meet all required diversions downstream. It is possible that water releases were constrained by Uzbekistan and Kazakhstan being unwilling or unable to accept more hydroelectric power, rather than the Toktogul operators being unwilling to release more water. Records show that in recent dry years Kazakhstan has received less than its agreed upon share of water. However, the timing and volumes of water deliveries to Kazakhstan may be largely due to problems in predicting and managing the water resources that originates below Toktogul Reservoir, which account in the average for 75% of the total water resources of the Syr Darya upstream of Chardara Dam in summer (see section 1.1).

40. Instructions for water releases and storage given by BVO Syr Darya to reservoir operators during the summer season are complied with, but recommendations by the BVO for releases and storage in winter are not always accepted. The managers of the Kairakum Reservoir operate in the winter to maximize generation to the detriment of downstream water users. The current operating regime of Kairakum and Chardara Reservoirs increases the spills to Arnasai Depression and the risk of flooding land and infrastructure in Uzbekistan and Kazakhstan. These reservoirs are already filled in January when releases from Toktogul Reservoir for power generation in Kyrgyzstan are highest. If Uzbekistan reduces the spillage into the Arnasai Depression, like this winter, there is an immediate risk of flooding urban (Kzyl Orda) and rural areas along the Lower Syr Darya in Kazakhstan.

2.5. Lack of Clarity in Water and Energy Agreements

41. The annual agreements specify water, fuel and power exchanges as follows:

(a) Exports of summer surplus electrical power from Kyrgyzstan to Uzbekistan and Kazakhstan usually in equal amounts of 1,100 GWh each;

(b) Imports of gas from Uzbekistan to Kyrgyzstan, and coal and fuel oil from Kazakhstan to Kyrgyzstan;

(c) Imports of winter electric power from Uzbekistan and Kazakhstan to Kyrgyzstan; and

(d) Toktogul Reservoir water releases by months for the summer and winter seasons.

42. Some agreements are multilateral and others are bilateral. The exchanges are spelled out differently from year-to-year; for example, the summer Toktogul Reservoir release may be specified for three months, four months, or for the entire six-month period. Some agreements specify winter water releases from Toktogul Reservoir, others do not. Some agreements, but not all, deal also with the operation of Kairakum Reservoir. Obligations of the parties change within the year if there is a significant change in the demand for water from Toktogul. If Toktogul Reservoir is called on to cut water releases, the result is a lower level of summer electrical power exports regardless of the original agreement.

43. The agreements are essentially about energy exchanges that leave a zero net balance, but the methods for of accounting for these exchanges are not fully clear. For example, the 2002 bilateral agreement between Uzbekistan and Kyrgyzstan mentions the following prices: 3.3 cents/kWh for hydroelectric energy exports from Kyrgyzstan and US $54 per thousand cubic meters (tcm) for Kyrgyzstan imports of gas. The price for electrical energy is much higher than the prevailing national wholesale prices within each Syr Darya country. This gas price is also much higher than the price of US $14 per tcm paid by Uzbekenergo as a fuel source for its power plants. Earlier this year, it was reported that Itera (a subsidiary of Gazprom) had agreed to buy Uzbekistan gas for US $40 per tcm for export to the Ukraine. Table 2 shows actual power and fuel exchanges for a five-year period. In years of high Toktogul Reservoir water releases, exports exceed imports and the reverse is true in years of low water release.

Table 2. Power and Fuel Exchanges: 1998 - 2003

	1998/99	**1999/00**	**2000/01**	**2001/02**	**2002/3**
Electric Energy: (GWh)					
Export from Kyrgyzstan	799	1,628	2,600	1,984	919
Import to Kyrgyzstan	75		195	287	267
Net Export	**724**	**1,628**	**2,405**	**1,607**	**652**
Fuel:					
Gas Import (mcm)	748	331	431	597	600
Value (GWh)	1,760	780	1,012	1,402	1,410
Coal Imports (tons X 1000)	150	538	331	597	600
Value (GWh)	195	700	430	776	780
Total Fuel (GWh)	**1,955**	**1,480**	**1,442**	**2,178**	**2,190**
Water:					
Toktogul Reservoir Releases (bcm)	**3.7**	**5.1**	**6.5**	**5.9**	**3.6**

44. The supply of fuel to Kyrgyzstan is erratic since it depends on power exports that, in turn, depend on the volume of water released from Toktogul Reservoir at the request of the downstream users. This can lead to problems for Kyrgyzstan whose fuel needs are relatively constant from year to year.

3. EVALUATION OF SHORT TO MEDIUM-TERM REMEDIAL MEASURES

3.1. Improved Operation of Toktogul Reservoir

45. Many of the problems associated with annual negotiations on water and energy exchanges and the difficulties of water and energy managers in preparing seasonal water resource management plans would be eased if the operation of Toktogul Reservoir were to be made more stable through the adoption of fixed operating rules. The purpose of improved operating rules would be to: (a) reduce water spill, (b) prevent emptying of the reservoir or drastic reductions in planned releases when the reservoir is nearly empty; (c) give more control of summer water releases to the downstream users; (d) make winter and summer power production more predictable; and (e) improve cooperation and reduce conflicts between the operators and downstream water users.

46. Analysis of the record of inflows to the reservoir, and river flows at the site before the reservoir was constructed, is hampered by a non-uniformity in the measurement methods over the record period (since 1912), cyclical wet and dry periods of several years, and an apparent recent trend of increasing flows. A TWEP analysis indicates that the average water inflow to the reservoir minus reservoir losses can be assumed to be at least 12.5 bcm per year. This is significantly higher than the uncorrected average long-term river flow of 11.7 bcm per year that is often quoted. Furthermore, a recent trend of increasing annual average flows indicates that the sustainable average reservoir release might be as high as 13.6 bcm per year.

47. A stable reservoir operating regime should set an agreed target for average annual water releases that is not too different from the average annual inflow. Distribution of the target annual releases between the summer (April-September) and winter (October-March) must be agreed as this is the main point of discussion or conflict between the countries in the river basin. Winter water releases are of interest to Kyrgyzstan for electricity generation. Summer water releases are primarily of interest to the main downstream users, Kazakhstan and Uzbekistan, for irrigation. In summer, Kyrgyzstan is also interested in minimum releases for electricity generation to satisfy national demand.

48. TWEP has examined historical release patterns over the period since the reservoir was commissioned in order to develop the reservoir operating rules described here. Releases from Toktogul for irrigation during summer vary considerably from year to year, depending on the availability of other water resources elsewhere in the basin. Over the period 1980-1994, ignoring excess releases when the reservoir was full, the average summer release was 7.5 bcm. Since 1995 this release has reduced to an average of 5.4 bcm. Winter releases over the same periods have increased from 3.8 bcm to 8.1 bcm. This is large increase that has been possible because of the increase in inflow to the reservoir, not, as sometimes quoted, by over-drawing the reservoir.

49. The recent pattern of releases from Toktogul has been supported by the agreed electricity and fuel exchanges under the 1998 agreement. In general, summer water releases have been in accordance with the requests made by the downstream countries. Thus, for the purpose of testing the reservoir operating rules, the target average summer water release has been set at 5.5 bcm. Assuming an average annual release of 12.5 bcm, the average target winter water release has correspondingly been set to 7.0 bcm. These non-winter water

releases would be managed from month to month by Kyrgyzstan to meet its own power generation needs.

> Rule 1: Target average releases should be agreed for the summer (April-September) and winter (October-March), the sum of which should not be much different from the long-term average river inflow to the reservoir less net reservoir losses.

50. During the summer, other Middle Syr Darya water sources such as tributaries and side inflows vary from year-to-year. Therefore, water releases from Toktogul Reservoir will need to be sometimes more and sometimes less than the target average release (5.5 bcm). The downstream countries routinely request a reduction in the reservoir release when other water resources in the basin are plentiful. Water that is saved in the reservoir when the release has been reduced below the target release should be made available for use by downstream riparians in subsequent years. The summer water releases and savings would be managed by maintaining a "Water Savings Account". The water savings account must include limitations that depend on the storage level in the reservoir at the time that requests are made (e.g. water cannot be saved if the reservoir is already full or withdrawn if the reservoir is nearly empty). There also should be limitations related to the minimum releases for electricity generation to satisfy Kyrgyz electricity demand. Within these limitations, Uzbekistan and Kazakhstan should be free to make adjustments to releases, provided sufficient notice is given to the reservoir operators to allow electricity generated to be properly distributed. Use of the BVO's Decision Support System (described below) would enable Uzbekistan and Kazakhstan to manage summer reservoir withdrawals and the "Savings Account" more efficiently, and to call for additional or reduced water releases earlier in the period than has previously been the case.

> Rule 2: Kazakhstan and Uzbekistan can vary their water withdrawals from Toktogul Reservoir during the summer, within constraints of: (a) maximum and minimum accounts of the water saved in the reservoir; (b) minimum water releases for electricity generation and diversion to canals on the Naryn River; and (c) availability of storage space in the reservoir.

51. Flexible management of summer water releases can only be achieved if complementary rules ensure that the Toktogul Reservoir is managed in a stable way. A common approach to reservoir operation is the use of "Rule Curves" that link operating decisions to current storage. The Reservoir Operation Rule Curves would be designed to automatically trigger decisions that: (a) increase winter releases if the reservoir storage is high and there is a risk of it being full and spilling during the following summer; and (b) reduce the water releases at any time of the year if the reservoir storage is low and there is a risk of it emptying or providing insufficient reserves for the following winter period.

> Rule 3: Reservoir Rule Curves, based on the water stored at the beginning of each 10-day period, will determine if the target releases for summer and winter (Rule 1) need to be increased or decreased to avoid emptying or overfilling of the reservoir. The Rule Curves will also be used to limit the amount of water that can be saved (Rule 2).

52. The above discussion relates to operating rules for Toktogul Reservoir in isolation, to meet both local (electricity generation) and downstream (irrigation) demands. However, the reservoir does not operate in isolation. A full set of arrangements for river basin management must also take into account the river inflows downstream of Toktogul as well as operation of

the other reservoirs in the basin to ensure stability of water management and to avoid risks of flooding. BVO Syr Darya's role in coordinating river management must be strengthened to integrate all such considerations. Nevertheless, the need for fixed operating rules for Toktogul Reservoir that are simple to operate and transparent to all water users is essential.

53. These operating rules are currently being developed in cooperation with officials in JSC Power Plants and BVO Syr Darya. Trials of the rules show that the approach is applicable and their application would maintain a stable pond and simplify annual negotiations and agreements on reservoir releases. Table 3 presents some results from the simulation. It shows that fixed rules would maintain the target average summer release (5.5 bcm). The "Water Saving Account" has debits and credits but no large accumulated balance. Importantly, the simulation also shows that variations in release from year to year could be larger than has previously been the case in order to better adjust to the very large variations in other water resources in the basin. During each of the recent "water-short" years such as 1997, 2000, and 2001 an extra 1.0 bcm could have been safely withdrawn from the reservoir. In turn, releases from Toktogul Reservoir should have been reduced in years such as 1996 and 1999 when the water was not needed so much. This "saved" water would then have been available for use in other years. Thus, application of the proposed rules would have resulted in reservoir releases that better suited downstream needs.

Table 3. Toktogul Summer Releases: Actual, Simulated and "Water Savings Account" (bcm)

Year	Actual Operation		Simulation of Fixed Rules		
	Release	Comment	Release	Saved	Balance
1995	6.3	Less than needed	7.4	-1.9	-1.9
1996	6.2	More than needed	4.6	+0.9	-1.0
1997	6.1	Less than needed	7.2	-1.7	-2.7
1998	3.7	As needed	3.5	+2.0	-0.7
1999	5.1	More than needed	3.8	+1.8	+1.1
2000	6.5	Less than needed	7.5	-2.0	-0.9
2001	5.9	Less than needed	7.3	-1.8	-2.7
2002	3.6	As needed	3.7	+1.8	-0.9
Average	5.4		5.6		

Short Term Operational Guidelines for the Naryn Cascade

54. The operating rules described above guide the management of water storage at Toktogul Reservoir and determine the volume to be released over periods of several days. While meeting these periodic water release objectives, the different plants in the Naryn Cascade must all combine their generation to follow the fluctuating load. The travel time of water between each pair of consecutive plants is under one hour and there are small but highly variable side inflows between them. Therefore, it is necessary to develop guidelines so that the longer term objectives of water release are combined with the electricity load pattern

and the side inflows to permit a smooth operation and prevent unnecessary spill at the plants downstream of Toktogul Reservoir. This management tool will help develop such operating guidelines for each water control facility (headpond, power plant or spillway) along the cascade to respond promptly to changes in side inflows or load conditions.

3.2. Improved Decision Support System for the Middle Syr Darya

55. Efficient operation of a reservoir and river management system depends on good data and information being available to the managers and good dissemination of information to the water and energy users. Deterioration of snow monitoring systems in Kyrgyzstan makes the prediction of summer water flows in tributaries imprecise. Moreover, there has never been a reliable method to predict water flows that reach the Syr Darya through drains, small streams, and groundwater, or losses from the river bed. Lack of clarity in the presentation of other river flow information also makes water management difficult.

56. Management of the Middle Syr Darya by BVO Syr Darya would be improved by upgrading their Decision Support System (DSS) to: (a) improve prediction of water resources; (b) maintain rolling plans of available water resources and canal diversions; and (c) provide the information needed by water users. Such an improved DSS would help the BVO Syr Darya to advise downstream countries on the summer water releases needed from Toktogul Reservoir early in the season. The DSS would help the BVO also to prepare more accurate plans for the allocation of the basin's water resources throughout the irrigation season. Key aspects of such a DSS should be improved prediction of water resources and improved clarity of information.

57. The DSS would enable the BVO to predict at the end of April what will be the available water resources from tributaries downstream of Toktogul Reservoir during the remainder of the irrigation season. If the sum of (a) the predicted water resource and (b) the target summer release from Toktogul Reservoir (see section 3.1) is less than the volume of required canal diversions plus the releases from Chardara Reservoir, the water managers in the downstream countries can decide whether to request increased flows from Toktogul Reservoir (thus above the target release) or to reduce canal diversions. In some years both measures will be needed. The managers would be able to identify water resource shortages earlier in the main irrigation season than has been the case in the past. The use of the DSS would also give the BVO firm evidence to support a recommendation to the countries for a reduction in canal diversions, which is always an unpopular action. If the total predicted volume is greater than required, the BVO Syr Darya might advise the downstream countries to request a reduction of the target release from Toktogul in order to save water in the reservoir for use during a subsequent year.

58. This DSS is being developed together with officials of BVO Syr Darya. Analysis of the past 13 years of river flows, canal diversions and reservoir operations has identified relationships that can be used to predict flows into the reservoirs on the tributary rivers and side inflows (see table 1). Thus, the total summer water resources can be predicted with increased accuracy. With the help of these predictive tools, the DSS will base water management planning on the balance between water resources and diversion needs. This will start at the level of the whole summer and winter period and the whole river basin. Subsequently, the DSS will cascade down to the detailed operational levels of individual canal heads and 10-day periods.

59. Tests of the principles of the DSS show that difficulties in managing scarce water resources, such as were experienced during the year 2000, could have been considerably alleviated. Whereas it was forecasted that non-Toktogul water resources in the summer of 2000 would be 86% of average, the DSS would already at the end of April have identified that the water resource to be only 65% of average. This forecast would have been little changed by monthly updates as the season progressed. In reality, canal diversions were high in the early season and had to be cut drastically in July to 71% of the Limits as it was eventually realized that the actual non-Toktogul resource would be only 64% of average.

60. An important benefit of the DSS would be the clarity that it would provide in timely data and information for water managers in all four basin countries. Increased openness in river management decision-making would help to increase trust between countries and institutions.

3.3. Reduction of Arnasai Spills

61. A World Bank financed project is under construction to help relieve this problem. Its objective is to increase the conveyance capacity of the Lower Syr Darya by removing and remodeling structures along the river. This should also greatly reduce the spills into the Arnasai Depression in Uzbekistan and make more water available for the Syr Darya Delta and the Northern Aral Sea, particularly during winter. At the same time, further steps are needed to improve the operation of the Kairakum and Chardara Reservoirs with a view to store more water when winter releases from Toktogul Reservoir are high (December-March). This would reduce the water flows that have to be discharged by the Lower Syr Darya towards the Northern Aral Sea. Improved operation of Kairakum and Chardara Reservoirs would also reduce the risk of flooding areas along the Lower Syr Darya in winter.

3.4. Improved Operation of Kairakum and Chardara Reservoirs

62. Adoption of appropriate rules for operating these reservoirs would reduce the high winter water losses into the Arnasai Depression to sustainable levels (about 1.0 bcm). It would also reduce the risk of flooding of areas along the Lower Syr Darya in winter. To reduce water losses and flooding risks, Kairakum and Chardara reservoirs should be filled during the winter season, thus later than currently practiced. In October / November, the reservoirs should remain at a low level, possibly emptying Chardara Reservoir before freezing starts in the Lower Syr Darya. This would increase the capacity of the Lower Syr Darya to transport water towards the Northern Aral Sea under the frozen river. The reservoirs would be filled during December- March when the releases from Toktogul Reservoir for power generation in Kyrgyzstan are high.

63. By operating the Kairakum Reservoir at a lower level during autumn, the associated hydroelectric power station would produce less energy than in the present situation. The modest amount of power generation forgone by Tajikistan would need to be compensated by Kazakhstan. The suggested change in operating regime of Kairakum Reservoir would be compatible with the agreement reached every year between Tajikistan and Uzbekistan that regulates water storage and releases from Kairakum Reservoir during the summer. It is recommended that the Syr Darya Basin countries explore the options for improved operation of the Kairakum and Chardara Reservoir.

3.5. New Water Storage and Transfer Projects

64. This report is concerned with better management of existing infrastructure. However, there are several water storage and water transfer projects underway or planned in the basin. The objective of most of these projects is to store part of the winter releases from Toktogul Reservoir for irrigation in the subsequent summer months (April-September). This new infrastructure could contribute to more national independence of water management decisions and more stable river management. It is recommended that the following projects be included in future detailed studies of the longer-term regional water management arrangements.

Arnasai Depression Pumping Scheme

65. Recently, Uzbekistan has constructed dikes, regulators and pumping stations around the Arnasai Depression. The aim is to store part of the water spilled from the Chardara Reservoir during the winter season for irrigation in Dzhizak Oblast (Hunger Steppe) in summer. The pump lift is about 50 m and it is envisioned to pump annually about 0.5 km^3 out of the Arnasai Depression.

Rezaksay and Kenkylsay Reservoirs in the Fergana Valley

66. Uzbekistan is developing plans to build two small reservoirs in the higher elevated fringes of Fergana Valley that would store surplus winter flows for irrigation in summer. The reservoirs would be built in stages with a total capacity of about 1.0 km^3. Rezaksay Reservoir with a storage capacity of 0.6 to 0.8 km^3 would be supplied with water from the Great Namangan Canal. Kenkylsay Reservoir with a storage capacity of 0.2 km^3 would be supplied with water from the Great Namangan Canal and, by pumping, from the North Fergana Canal.

Chirchik Valley Water Transfer

67. The aim of this scheme would be to relieve irrigation shortages in the Syr Darya and Dzhizak Oblasts in Uzbekistan by annual diversions of 0.5 to 1.0 km^3 from the Chirchik-Akhangaran Basin. The plan involves the construction of the Pskem Reservoir upstream of Charvak Reservoir, the improvement of the Tuyubuguz Reservoir on the Akhangaran River, new canals, and a crossing of the Syr Darya. The Pskem Dam would mainly serve hydropower interests but reportedly its costs are high.

Koksaray Reservoir

68. Kazakhstan has investigated the use of depressions at Koksaray for storage of excess winter flow in the Lower Syr Darya, downstream of Chardara Reservoir. The aim would be to use the stored water for irrigation and for maintenance of an environmental flow in the Syr Darya Delta during the summer months. The feasibility study considered various project designs. It was found that the project is too costly with low economic returns. In 2002, Kazakhstan decided not to pursue the construction of Koksaray Reservoir further at this point in time.

Improvement of Kairakum Reservoir

69. The Kairakum Reservoir in Tajikistan has a gross capacity of 4 km3 and a live storage of 2.6 km3. Due to structural and operational problems, the live storage is not used to the maximum capacity to release water during the summer for irrigation, or to reduce winter

flows to lower reaches of the river. The envisioned project would remove the bottlenecks that prevent the full use of the live storage capacity. In addition, the project would enable the use of the flood reserve capacity of about 0.5 km3 by rehabilitating and heightening dikes and improving the drainage system along parts of the western bank of the reservoir.

3.6. Improved Arrangements for Fuel and Power Exchanges

Rationale for Improvement

70. The Naryn Cascade is a strategic power resource of Kyrgyzstan as it contributes the largest component of the electric energy and capacity of the Kyrgyz generation system. The power plants of the Naryn Cascade and other small hydroelectric facilities plus the existing thermal plants can produce, given enough fuel, about 26% more than the current annual electric energy demand. This demand level includes total losses of about 44%. A minor part of these losses are normal technical losses, others are technical and non-technical losses that can be eliminated from the demand. A considerable portion of the losses merely constitutes unbilled deliveries that are an intrinsic part of the demand.

71. Compared to historical patterns, the use of the proposed fixed rules for operating Toktogul Reservoir would result in larger year-to-year variations in the summer electric energy produced by the Naryn Cascade and smaller year-to-year variations in winter electric energy generation. The summer electric energy surplus of Kyrgyzstan would range from nearly zero to about 3,000 GWh with an average of 1,910 GWh. Under average conditions and at current load levels, Kyrgyz thermal plants would require fuel imports for an average annual production of approximately 1,965 GWh.

72. A sustainable long-term management system for the Toktogul Reservoir must recognize all the implications of the multiple-purpose utilization of this resource upon the Kyrgyz power generation system. The clearest implication is of course a seasonal pattern of downstream water release requirements inverse to that of electricity demand. But there are other impacts including the effect on firm energy and peaking capability that will be felt, as the Kyrgyz generation system needs to expand its capacity, and the Naryn Cascade becomes increasingly a source of peak power for the country.

73. If the electricity and heat customers in Kyrgyzstan could tolerate tariffs close to the economic cost of service, including international market prices for fuel, then Kyrgyzstan could conceivably use the storage at Toktogul Reservoir to its best power supply advantage, import fuel as needed, and use any revenues from hydroelectricity exports to help lower the economic cost of service. However, even under this improbable scenario, the market for hydroelectricity exports to neighboring countries is unclear and indeed would be very doubtful if transboundary water management issues are not satisfactorily addressed. Therefore, it is in the best interest of Kyrgyzstan to continue to fully cooperate in water and energy issues with the downstream countries. In the short term, the first priority is to stabilize the supply of fuel to Kyrgyz thermal plants, recognizing that thermal generation requirements are already higher than average hydroelectric exports, thus presenting the power sector with a growing energy trade deficit problem.

74. It is therefore concluded that a) the need for continuing regional cooperation in the management of the water and energy resources of the Syr Darya basin is unquestionable, b) the 1998 Framework Agreement provides solid principles for this cooperation and c) all parties would benefit greatly from a manner of implementation of the Agreement that would eliminate uncertainties about quantities of water and energy transferred each year.

75. As a corollary to this conclusion, two complementary measures are suggested. The first measure is focused on resolving the near term problem of variability of hydroelectric exports and associated fuel imports. This near term measure represents a relatively small change to current practices but it would stabilize the annual fuel deliveries to Kyrgyzstan. Two options are described for this purpose and either one will eliminate the uncertainties about quantities of water and energy transferred each year without the need for a single tariff policy or the replacement of barter exchanges.

76. The second measure is suggested for the medium or long term and consists in the development of a comprehensive Regulatory Framework to the 1998 Framework Agreement. This will consist of a permanent set of guidelines for the development of a single tariff policy and would include the rules for an energy exchange pool administered by the International Water and Energy Consortium (IWEC).

Near Term Measure to Stabilize Fuel Deliveries

OPTION 1 – A MULTI-YEAR ELECTRICITY-FUEL EXCHANGE PROTOCOL BASED ON PAST FUEL DELIVERIES

77. The use of the fixed rules for operating Toktogul Reservoir would result in larger year-to-year variations in summer hydroelectricity produced by the Naryn Cascade and smaller year-to-year variations in winter hydroelectricity generation. Stability in supply of fuel would be achieved if Kazakhstan and Uzbekistan were to agree to supply an average of the fuel quantities delivered over the past few years at current price levels. These quantities can be subject to annual adjustments up or down at the request of Kyrgyzstan. The agreement can be in the form of a multi-year electricity-fuel exchange Protocol that would aim to balance varying power generation that has resulted from varying summer releases from Toktogul Reservoir with a steady fuel supply to Kyrgyzstan.

78. This option is in line with present practices but would simplify the difficult annual negotiations on water and energy exchanges. The fuels would provide for operation of the thermal plants. This would still leave the problem of Kyrgyzstan's modest energy shortfall. Until demand has been reduced, or Kyrgyzstan has the capacity to purchase additional imports, the only option will be load shedding. This in turn could make it harder for Kyrgyzstan to maintain the proposed rules for operating Toktogul Reservoir.

OPTION 2 – A MULTI-YEAR ELECTRICITY-FUEL EXCHANGE PROTOCOL BASED ON FUTURE ENERGY EXCHANGES

79. Implementation of the proposed rules for operating Toktogul Reservoir would practically avoid the need to release water just for water level control. There would be no need to release water from the reservoir in excess of the water demand by Uzbekistan and Kazakhstan. Therefore, a main principle of this option is that all power generated by the Naryn Cascade that is in excess of Kyrgyzstan's national needs would be bought by Uzbekistan and Kazakhstan. These countries would buy this hydroelectricity at negotiated prices H_{UZ} and H_{KZ}, provided the power has been generated as a result of application of the agreed rules for operating Toktogul Reservoir. According to the 1998 Framework Agreement, Uzbekistan and Kazakhstan must share this surplus hydroelectricity in equal portions.

80. Fuel deliveries from Kazakhstan and Uzbekistan to Kyrgyzstan in exchange for the electricity imports would be made, at negotiated prices F_{UZ} and F_{KZ} under a multi-year

electricity-fuel exchange Protocol that is linked to the agreement on long-term average seasonal releases from Toktogul Reservoir. The Protocol would aim to balance varying power generation that has resulted from varying summer releases from Toktogul Reservoir with a steady fuel supply to Kyrgyzstan.

81. This option would provide an additional incentive to Kyrgyzstan to maintain the agreed Toktogul Operating Rules that would make the operation of the reservoir more responsive to the demands of Uzbekistan and Kazakhstan. The multi-year contract would possibly avoid the need for annual negotiations and political approval on fuels and power transfers.

82. Guidelines for negotiating prices H_{UZ}, H_{KZ}, F_{UZ} and F_{KZ} in accordance with the principles of compensation established by the 1998 Agreement would be developed. The prices would represent a reference for settlement but this does not necessarily mean that transactions must be settled in cash. Barter transactions can continue between any parties that prefer to transact in this manner. Furthermore, it is immaterial whether barter or cash is used to settle export-import balances.

Medium Term Measure - Design of a Regulatory Framework for Implementation of the 1998 Framework Agreement

83. The 1998 Framework Agreement clearly reflects the policy and fundamental principles of cooperation of the signatory states. There are several references in the Agreement to the need to establish a **Regulatory Framework** for its smooth implementation. Articles IV and X declare the need to establish a single tariff policy. Article V compels the Parties to undertake essential measures to ensure the fulfillment of the commitments of the Agreement. Also, the regulatory function is clearly assigned to the BVO Syr Darya and UDC Energia to determine the schedules of water and energy transfers prior to the establishment of the International Water and Energy Consortium (IWEC) and its executive body. It therefore appears that a practical Regulatory Framework for implementation of the 1998 Agreement would be a natural and important step towards the creation of the IWEC.

84. A practical **Regulatory Framework** would set clear rules for tariff determination, including power transmission and ancillary services fees and fuel transport fees. The Framework would recognize the difficulties in Kyrgyzstan associated with a highly variable level of hydroelectric exports and associated fuel imports. Addressing these issues would ensure the sustainability of the 1998 Agreement and derive maximum benefit from it for all parties. The following aspects could be included in the Regulatory Framework for the 1998 Framework Agreement.

SINGLE TARIFF POLICY

85. The spirit of the 1998 Agreement is clearly stated in Article IV establishing that equivalent energy be the principle of compensation and that a single tariff policy should be used for all energy transactions and associated transportation. This enables the agencies charged with implementation of the Agreement to determine fair tariffs for all transboundary energy transfers using the concept of opportunity costs, thereby simplifying the process of annual tariffs agreements. The opportunity cost to Kyrgyzstan of delivering power to Kazakhstan and Uzbekistan (instead of storing water for winter generation) is the cost of generating that power with its thermal plants. Similarly, the cost to Kazakhstan and Uzbekistan of delivering fuel to Kyrgyzstan must be recognized and fairly compensated.

86. For this purpose the Regulatory Framework could establish reference thermal plants in Kyrgyzstan and reference substations in Kyrgyzstan, Uzbekistan and Kazakhstan that would represent the geographic point where power is consumed. Next there would be a determination of the thermal efficiency of the reference plant and the transmission losses between the reference plant, the Naryn Cascade, and the reference substations. Finally, the heating values of the different fuels used for compensation would be determined. With these data the amount of each type of fuel offered in compensation for hydroelectric power delivered can be promptly and fairly calculated.

TRANSBOUNDARY ELECTRICITY AND FUEL EXCHANGE POOL (TEFEP)

87. Article V of the 1998 Agreement states that the Parties shall undertake essential measures to guarantee the fulfillment of their commitments. Article X states that the Parties shall consider the replacement of barter settlements by financial relations. Once a clear process is defined for establishing the tariffs at which energy transfers are to be settled, and then the objectives of the Agreement can be best achieved based on the "pool" concept. Electricity pools are extensively used around the world to allow separate owners of electric generation equipment to share the benefits of a combined use of their assets. In this case the parties would set a unique example of regional cooperation by sharing the use of water storage facilities, hydroelectric plants, thermal plants, fuel production facilities, transmission grids and fuel delivery networks. The benefits are the timely delivery of water and energy to all members of the pool.

88. In practical terms, the three countries would establish a **Transboundary Electricity and Fuel Exchange Pool (TEFEP**) tied to the 1998 Framework Agreement. All electricity and fuel deliveries will be booked at the tariff schedule defined by the single tariff policy described above. Countries will be free to solicit and obtain from the TEFEP the resources they require. In the case of Uzbekistan and Kazakhstan, these will be water releases and the associated hydroelectric surplus of the Naryn Cascade during the summer irrigation season. In the case of Kyrgyzstan these will be the fuel deliveries required to meet thermal generation needs during the winter.

89. Detailed rules for the TEFEP will have to be developed and discussed at length as there are many options. However, some basic principles are suggested to illustrate the concept as follows. The pool will offer flexibility and stability by not requiring that all transactions balance on an annual basis but rather on a 3-year or longer period. However, to avoid the possibility of cumulative imbalances the TEFEP will limit the balance of any participant to not exceed three times the average annual amount of transboundary exchange. These averages will be derived from a simulation of Kyrgyz demand and Toktogul Reservoir operation under the rules using average water release requirements. At the end of each 3-year period the accounts will be settled by cash transfers (or negotiated credits against the next 3-year period balance). The same process applies if within a 3-year period the debt of one participant to any other participant exceeds 3 times the annual balance that could have been expected under average conditions.

90. The prices defined by the tariff schedule represent a reference for settlement but this does not necessarily mean that transactions must be settled in cash. Barter transactions can continue between any parties that prefer to transact in this manner, and it is immaterial whether barter or cash is used to settle export-import balances.

91. The TEFEP is a natural step towards the implementation of the IWEC as it can eventually be expanded to include all exports and imports of energy among the participants beyond merely those associated with the Naryn Cascade (see section 4.5).

3.7. Demand Management in Kyrgyzstan

92. It is imperative that regulatory reforms are taken to raise tariffs for cost recovery, provide balance between demand and available supplies, cut technical and non-technical losses, create an environment for energy conservation, and increase collection rates. USAID is currently supporting an energy efficiency and loss reduction demonstration program with the five Kyrgyz power companies. Part of a World Bank loan will be used to replicate the demonstration projects in a much larger area. The World Bank and some other donors plan to complement this program by supporting legal, regulatory, and institutional actions that will improve the strength of the State Energy Agency and management of the distribution companies.

3.8. Strengthening of Existing Water Management Institutions

93. Several options have been suggested by the international community to improve regional water management. However, since the existing arrangements work reasonably well, major changes are not considered appropriate in the medium term. Adoption of the rules for Toktogul Reservoir and the multi-year electricity-fuel exchange Protocol would simplify and stabilize river management by allowing national independence in operation and implementation by technical staff without the need to regularly refer for political approval. But there is a need to improve the seasonal planning, monitoring and information sharing between the countries. Particularly, more complete, transparent, and timely reporting of reservoir operations, river flows, and canal head diversions would diminish friction between the four countries and promote cooperation.

94. Seasonal planning, monitoring, and reporting are essentially functions of the BVO Syr Darya. The performance of the BVO in these areas would be improved by the adoption of reservoir operating rules and the use of the DSS for the Middle Syr Darya. Other measures that should be taken include: (i) better river flow measurement; (ii) better understanding of losses and environmental releases and other issues in the Lower Syr Darya; and (iii) better communication between the BVO Syr Darya and the Unified Dispatch Center and national water and energy agencies. The ICWC should consider a request to the BVO Syr Darya to prepare, in consultation with the above agencies, a detailed plan for the strengthening of its seasonal planning, monitoring, and information and data sharing function.

4. EVALUATION OF MEDIUM TO LONG-TERM REMEDIAL MEASURES

4.1. Reform and Investments in the Power Sector

95. The electric power sectors in Kyrgyzstan, Kazakhstan, Tajikistan, and Uzbekistan suffer from numerous structural and institutional weaknesses that stand in the way of development of an integrated market for fuel and electrical power. Cost-based tariffs, combined with high collection rates, and technical and non-technical loss reduction would, in a relatively short period, pave the way for financial viability and investment in the modernization of electric power facilities. Regulatory reform will promote energy conservation, thus dropping demand considerably, as customers would be forced to pay cost-based tariffs.

96. At the same time, bilateral and multilateral energy trade agreements within the interconnected CAPS would allow for efficient and effective supply and demand for electric power in the region. Additionally, the ability for Kyrgyzstan to purchase reliable fuel supplies to meet its thermal power, district heat, industrial, and residential demand would go a long way to reduce electric power use in the winter. Such reforms would eventually eliminate the winter energy shortages that are at the core of the current regional water and energy problems.

4.2. Reform, Training, and Investments in the Irrigated Agriculture Sector

97. Irrigated agriculture suffers from a lack of public investment in operation, maintenance, and rehabilitation of the main systems. At the farm level, the systems are also in disrepair and the returns from agriculture provide little incentive for better water management and cost recovery. These problems lead to considerable inefficiencies in water use. Reform and training on the efficient use of the irrigated agriculture sector could greatly reduce water demand, and thereby ease the basin-wide problems of water distribution in water-short years.

4.3. Develop Hydroelectric Resources in Kyrgyzstan

98. The main undeveloped hydroelectric resources of Kyrgyzstan are the Kambarata 1 and Kambarata 2 projects upstream of Toktogul on the Naryn River. Kambarata 1 with an installed capacity of between 1,200 and 2,000 MW could produce about 4,600 GWh. It is a long-term prospect that would face formidable problems of financing. Kambarata 2, a smaller 300-400 MW project, would produce about 1,300 GWh, of which only about 400 GWh would be in the winter if it were to be constructed without Kambarata 1.

99. These projects could conceivably assist in meeting Kyrgyz electric power demand and earn Kyrgyzstan additional export revenue that could be used to buy fuel for its thermal power plants. However, three important aspects must be taken into account when contemplating the prospect for these projects: 1) the power sector of Kyrgyzstan currently does not earn enough revenue to finance them, 2) power markets in the region are unlikely to have prices that would make them economically attractive, and 3) fuel to Kyrgyzstan must come from or across Uzbekistan and Kazakhstan. It is therefore highly advisable that any project in Kyrgyzstan that could impact on the regime of water downstream be developed only after seeking agreement from countries potentially affected.

4.4. Develop Fuel Resources in Kyrgyzstan

100. In the 1980's, over one million tons of coal was mined annually in Kyrgyzstan, but production is now down to 100,000 tons a year. A new mine-mouth thermal power plant is a possibility that needs further investigation.

4.5. Establishment of New Regional Institutions

101. Several options have been suggested to improve regional water and energy management, including a River Basin Commission and a Water and Energy Consortium. The GEF Water and Environmental Management Project suggests the existing institutions move towards the model of a River Basin Commission. The commission would consist of a Council of (Vice) Prime Ministers, a joint committee of water and energy ministers of each of the basin countries, a permanent secretariat, and an inspectorate. Such a commission could be formed by broadening and strengthening existing regional institutions (such as ICWC). The inspectorate could evolve from internationalizing and strengthening the planning, monitoring and information sharing function of the current BVO Syr Darya. The Secretariat would not need to be a large organization.

102. The development of new energy resources that include the multiple purpose use of water in the region could be best achieved by the formation of an International Water and Energy Consortium (IWEC). The consortium could have several functions including the following:

(a) Regulatory Function. This function aims to enhance the operation of existing infrastructure and facilitate the best use of water and energy resources among the countries. Some of the activities of this function are: a) preparation of water balances (volume of consumption, accumulation and releases) for each reservoir of the Naryn/Syr Darya Cascade; b) adherence to the earlier agreed water shares for each country of the transboundary Syr Darya river; c) preparation and implementation of common legislation for all states to ensure legal basis for joint utilization of water and energy resources of transboundary rivers; d) harmonization of prices, taxes, customs and tariff policy in the field of joint usage of water facilities. Under Option 3 discussed in section 3.5.3 the IWEC will be the administrator of the proposed Regulatory Framework for the 1998 Framework Agreement.

(b) Planning Function. This function aims to plan the development of new water and energy infrastructure and includes the following activities: a) the formulation of a regionally consistent water and energy policy; b) the development of studies of water and energy projects at inventory, pre-feasibility and feasibility level; c) the definition of regional priorities on the basis of maximum regional benefit.

(c) Development Function. This function implements the regional plans and pools regional resources to seek financing or attract investors for the development of new water and power infrastructure.

(d) Trading Function. This function seeks to expand the horizons of the regional water and energy infrastructure to open markets outside the region. These markets can be pursued by combining the production capacity of one consortium member with the transport capacity of another and the fuel reserves of a third one. In this manner, firm contracts of energy at competitive prices can be sought in neighboring regions, which will help finance new infrastructure and provide export revenue to the Consortium participants.

5. CONCLUSIONS AND RECOMMENDATIONS

103. This Report recommends that:

(a) The Syr Darya Basin countries continue to abide by the "1998 Framework Agreement on the Use of Water and Energy Resources between the Syr Darya Basin Countries."

(b) The Syr Darya Basin countries agree to adopt and implement Toktogul Reservoir Operating Rules that would make the operation of the reservoir more responsive to the water demands of Uzbekistan and Kazakhstan during the summer irrigation season (April-September). The rules would provide the downstream countries with the opportunity to save water in the reservoir during years when other water resources are plentiful, for use in subsequent "dry" years when other water resources are low. The rules would also prevent over-filling or completely emptying of the reservoir.

(c) The Syr Darya Basin countries agree on a Multi-Year Electricity-Fuel Exchange Protocol as an urgent measure that would give Kyrgyzstan more stable fuel supplies in exchange for the variable surplus hydroelectricity generated at the Naryn Cascade as a result of water releases from Toktogul Reservoir requested by Uzbekistan and Kazakhstan.

(d) The Syr Darya Basin countries agree to develop a Regulatory Framework for the 1998 Agreement as a permanent guideline to the implementation of the Agreement. This will consist of guidelines for the development of a single tariff policy, including power transmission and fuel transport fees, and would include the rules for a regional energy exchange pool in line with the objectives for operation of existing facilities by the International Water and Energy Consortium.

104. Items (b) and (c) might be in the form of an Addendum to the 1998 Framework Agreement. There is no reason to revise the 1998 Framework Agreement since its principles are accepted and agreed by all parties. Item (d) is a more ambitious goal and should be subject to careful design. Such a Regulatory Framework will constitute a model of regional cooperation.

105. It is recommended that the Decision Support System (DSS) be adopted by the BVO Syr Darya. This is a refinement of existing procedures and would not require an interstate agreement. The DSS would help to determine early in the irrigation season the water demands of Uzbekistan and Kazakhstan from Toktogul Reservoir, and thereby allow time for the energy managers in these countries to plan the use of the summer surplus of hydroelectric power. The DSS would also allow timely changes in the water allocation plans throughout the irrigation season.

106. It is recommended that the Operational Guideline for the Naryn Cascade be adopted by JSC Power Plants. This management tool would help implement the proposed Toktogul Operating Rules in harmony with the daily and hourly management of water releases to account for sudden changes in electricity demand and tributary flows into the Cascade.

107. The adoption of the reservoir operating rules and the multi-year electricity-fuel exchange Protocol would simplify and stabilize river management, reduce water spillage, provide greater energy security to Kyrgyzstan and water security to downstream users, and

possibly avoid the need for annual negotiations and political approval on fuel and power transfers.

108. Radical changes in the institutional arrangements for regional water management are not considered appropriate in the medium term. But there is a need to improve the seasonal planning, monitoring, and information sharing to gain the confidence of the Syr Darya Basin countries that BVO Syr Darya is impartial in carrying out its duties. The management tools linked to better data reporting would improve the performance of the BVO in these areas. Other measures that should be taken include better river flow measurements, fuller understanding of the requirements of the Lower Syr Darya, and better communications between the BVO with various regional and national water and energy agencies.

109. It is further recommended that the Syr Darya Basin countries explore the options for improved operation of the Kairakum and Chardara Reservoir.

110. The ICWC could consider establishing a working group to assist the BVO Syr Darya to prepare a plan for the strengthening of its seasonal planning, monitoring and information sharing function, and to assess the options for improved operation of the Kairakum and Chardara Reservoir.

111. This Report notes that the Syr Darya countries should vigorously pursue energy sector reforms. These would pave the way for investments in power generation capacity that would help to eliminate the winter energy shortages that are at the core of the present water and energy problems in the Syr Darya Basin.

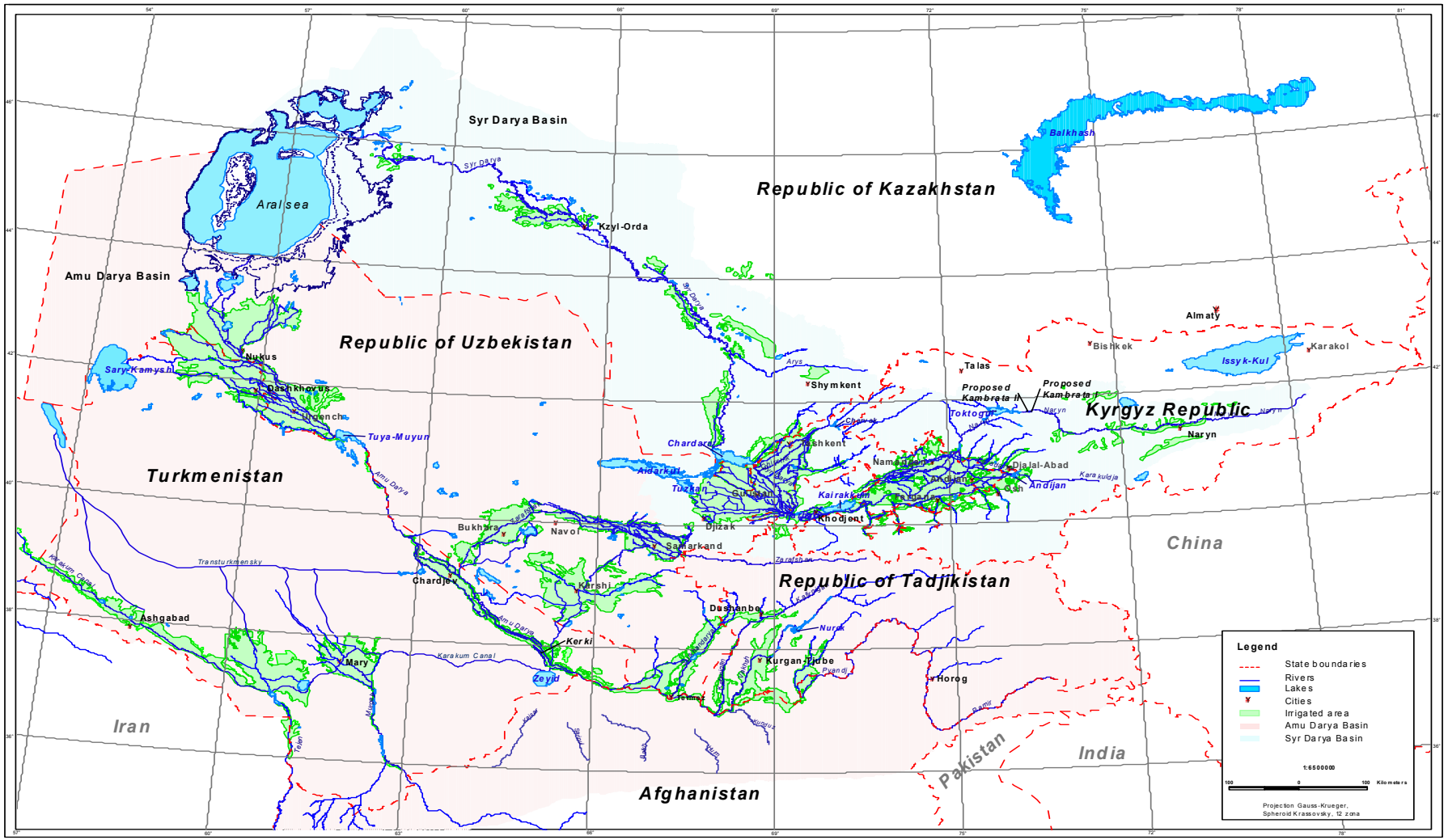

Figure 1. Aral Sea Basin

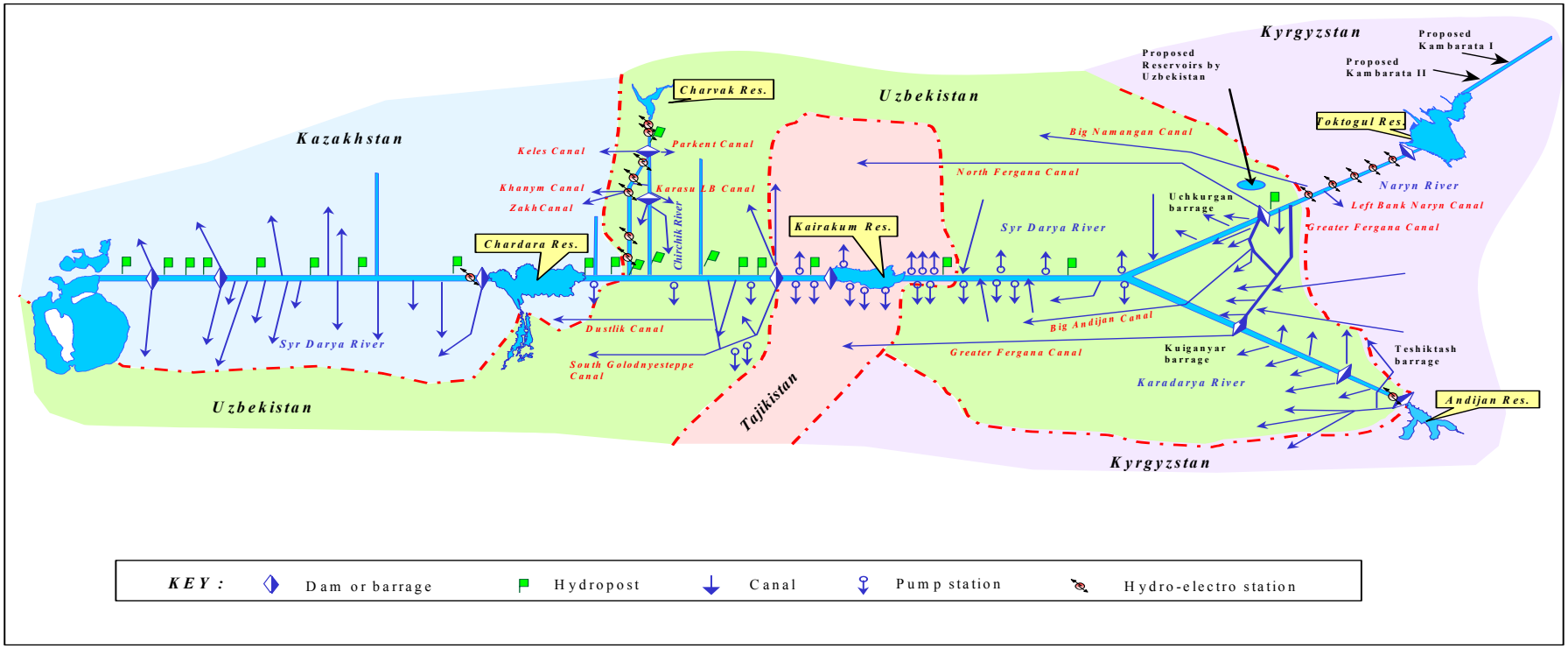

Figure 2. Water and Hydropower Facilities of the Syr Darya Basin